X-ray imaging without lenses: diffraction microscopy at Stony Brook and the ALS

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In 1952, Sayre proposed that a real space image could be obtained directly from diffraction data sampled at twice the frequency of Bragg diffraction[1], and in 1999 J. Miao *et al*. at Stony Brook obtained the first reconstructed x-ray image by this technique[2]. This technique offers a route to 3D imaging of whole-cell-sized specimens at a resolution limited only by the maximum radiation dose that a dry or frozen hydrated specimen can tolerate, without any losses due to zone plate efficiency or modulation transfer function rolloff at high spatial frequency. Recent estimates by Howells *et al.* suggest that 10 nm 3D resolution might be attainable on whole cell specimens. This approach requires a computational method for phasing the diffraction data in order to obtain a real space image; algorithms for this have been developed by many researchers including Feinup[3] and Elser[4], with much recent progress. We have built an apparatus for diffraction imaging which has the capability to work with frozen hydrated specimens rotated over a +/-80 degree tilt range for 3D imaging, and to obtain low resolution zone plate images as well so as to provide information at low spatial frequencies that is otherwise difficult to obtain from diffraction measurements alone. This apparatus operates at beamline 9.0.1 at the Advanced Light Source where it is used for experiments both by the Stony Brook group, and also for experiments[5] by Howells *et al*. at the ALS, Spence *et al.* at Arizona State University, and Chapman *et al.* at Lawrence Livermore National Laboratory. Recent experimental results will be reported, including images of yeast and studies of radiation damage effects. Future experiments at harder x-ray energies are also discussed. We thank NIH for support under grant 1 R01 GM64846-01, and the DoE for support under contract DE-FG02-04ER46128.

References

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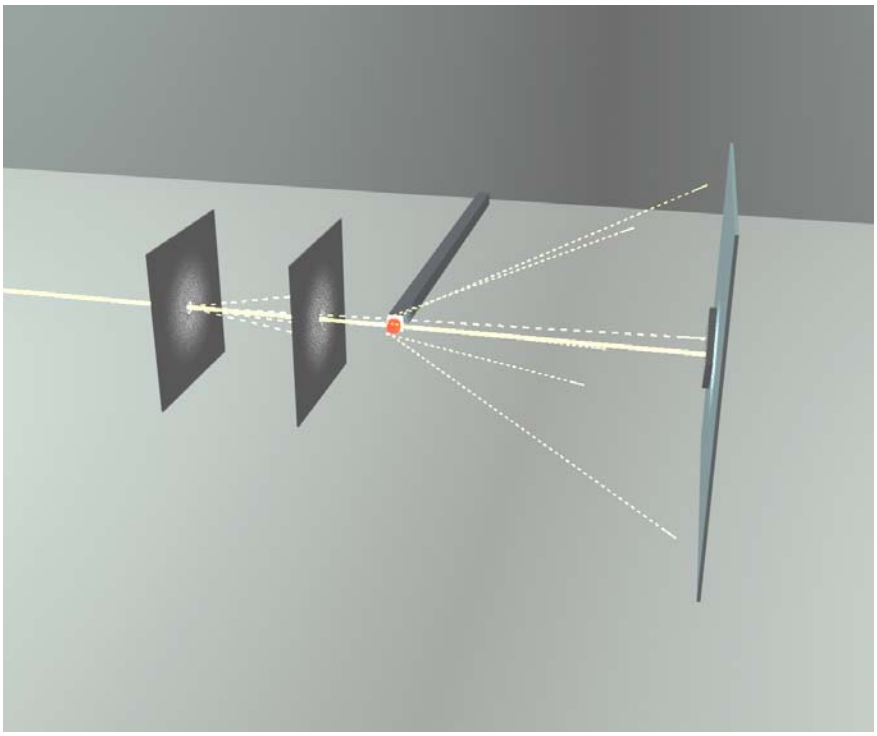

Fig. 1: essential items of the diffraction apparatus in use at the ALS

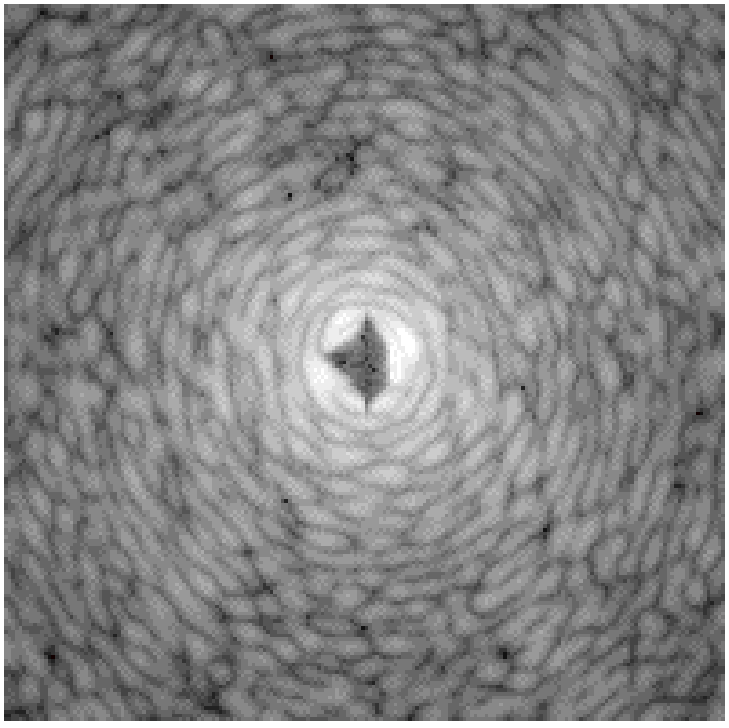

Fig. 2: soft x-ray diffraction pattern from a freeze-dried yeast cell.